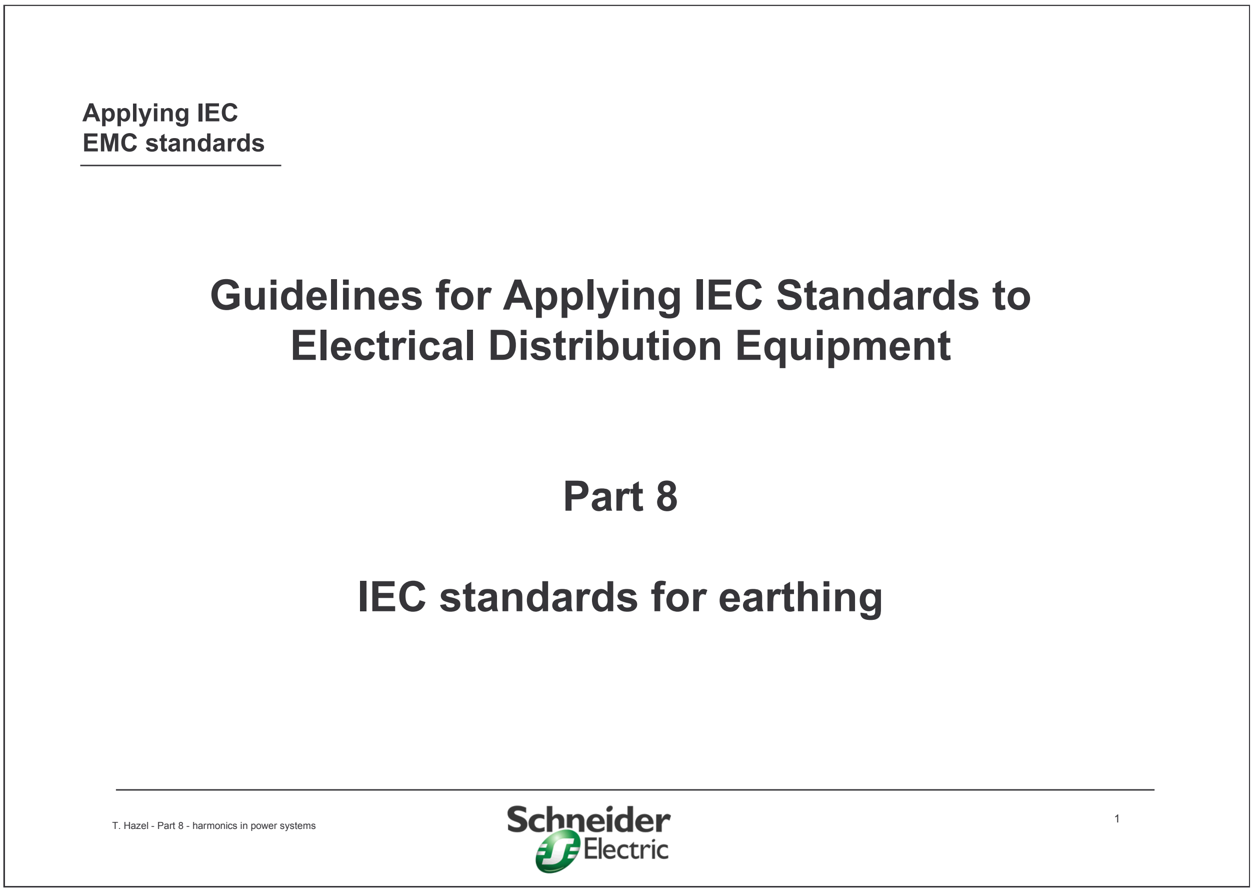


Guidelines for Applying IEC Standards to Electrical Distribution Equipment

Part 8

IEC standards for earthing

introduction

With the increasing use of variable speed drives and other power electronic devices in industrial applications, disturbances due to the presence of harmonic voltages and the flow of harmonic currents in power systems are becoming more frequent.

The IEC has developed a series of standards and technical reports, the aim of which is to try to prevent such problems from occurring. This part of the tutorial describes the basic structure of the IEC EMC (Electromagnetic Compatibility) standards and how they are used. Since earthing (grounding) is a major factor in all EMC considerations, this subject will also be discussed in this part.

basic principles of earthing

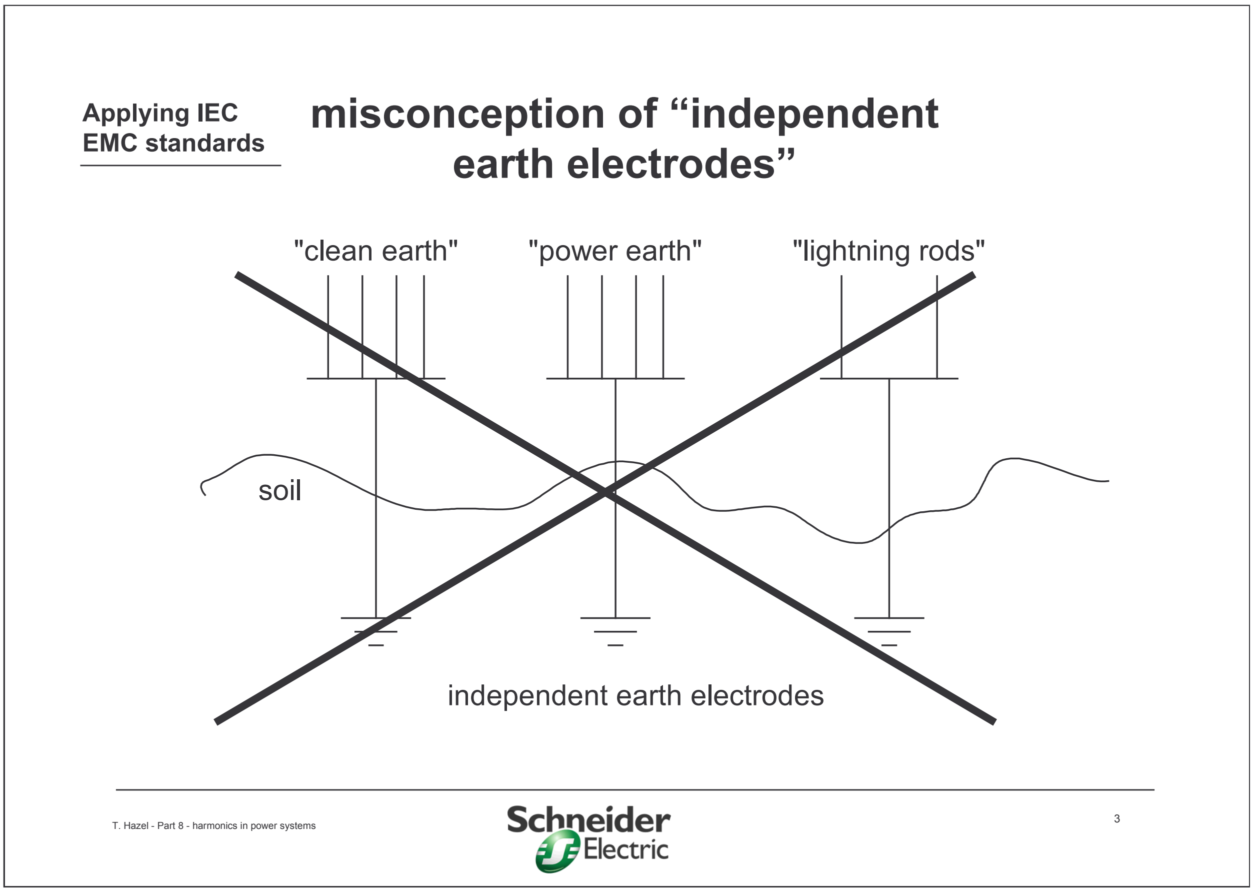
- lightning & personnel safety dictate design of earth electrode
- safety & installation protection dictate size of earthing conductors
- EMC behavior requirements determine layout of earthing network

Design of earthing system

The shunting of unwanted power-frequency currents, and lowering the voltage difference between points of an installation are requirements common to:

❑ lightning protection
❑ personnel safety
❑ installation protection
❑ EMC

The earthing system as a whole contributes greatly to satisfy these objectives. The same earthing system is used for all points mentioned above, which means that the earthing system must satisfy the requirements of each. Personnel safety remains the most important design criteria for earthing systems.



Applying IEC EMC standards

misconception of "independent earth electrodes"

T. Hazel - Part 8 - harmonics in power systems

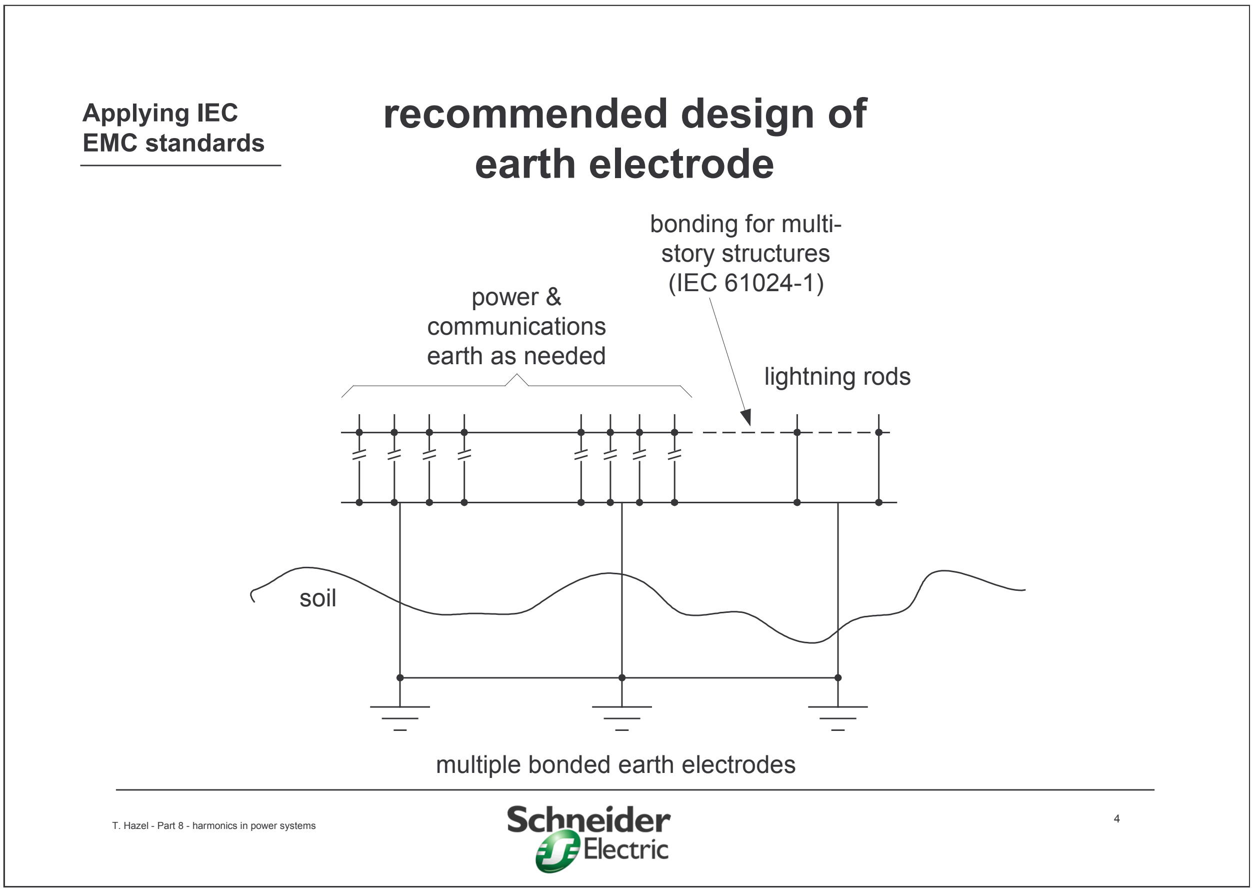
Schneider Electric

3

common mistakes

Most engineers are now aware that independent earth electrodes within an industrial or commercial complex do not exist. There is always coupling between them due to their proximity.

In spite of this there are still many installations that frequently suffer damage due to the incorrect interconnection of earthing electrodes. One of the main causes for damage is lightning. The misconception of an independent lightning system earth electrode is widespread and, in addition to being a safety hazard, results in the destruction of large quantities of sensitive equipment each year. An "independent" earth electrode is also totally unacceptable for EMC.



recommended design of earth electrode

bonding for multi-story structures (IEC 61024-1)

power & communications earth as needed

lightning rods

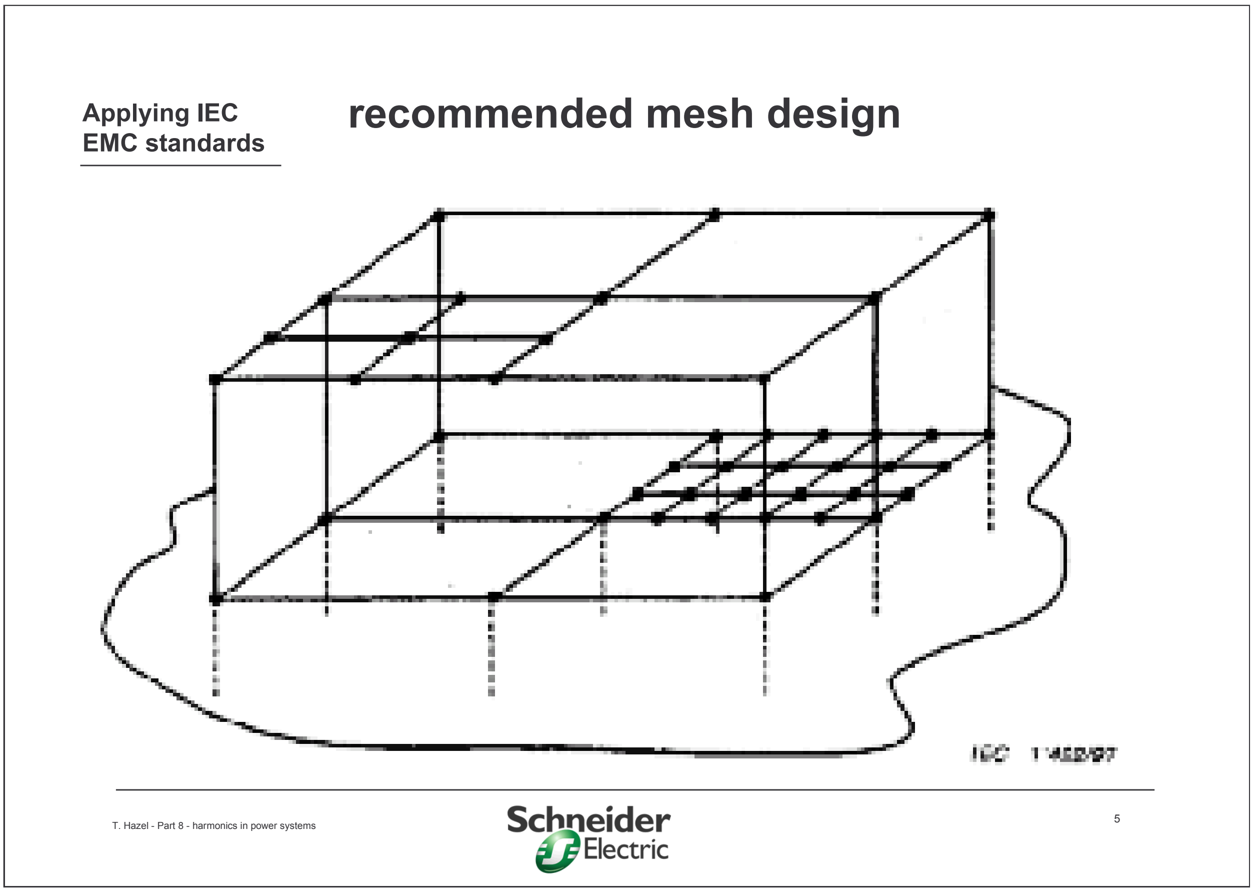
soil

multiple bonded earth electrodes

Recommended earth electrode design

The earth electrode must be common for the installation. The lightning protection system, power earthing conductors, and all other earthing conductors should be connected together as shown. For tall structures it is recommended to bond the lightning protection system conductors to the building earthing system every 20m (this concept is not universally accepted but considered good practice).

Although shown in 2 dimensions, the earthing system should be considered as a 3-dimensional mesh. Each floor has a mesh grid, and these grids are interconnected at several points between floors.



Applying IEC EMC standards

recommended mesh design

T. Hazel - Part 8 - harmonics in power systems

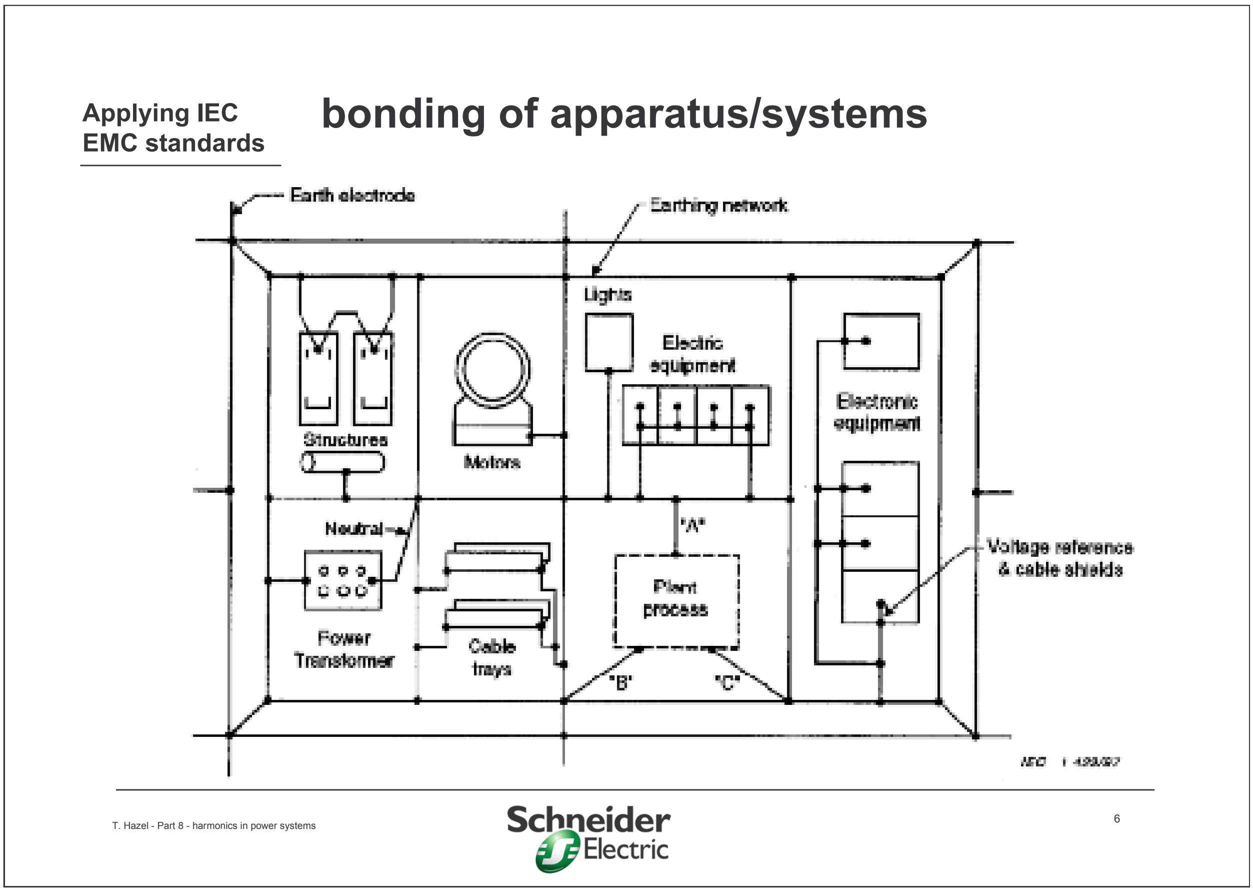
Schneider Electric

5

Mesh design

The mesh design is very effective since there are many parallel paths to each connection point. This is especially important for high frequency currents since at certain frequencies some paths will have almost infinite impedance due to their length being close to the wave length of the disturbance. The parallel path having a different length will ensure good earthing at such frequencies.

The mesh design is also good from a safety point of view since the loss of one conductor will not result in unearthed equipment. The parallel conductors also produce a Faraday cage effect which is especially important in rooms housing data processing equipment. A ground plane is achieved underneath the equipment by installing an interconnected mesh. This ground plane serves as a reference plane for the data processing equipment and helps reduce the coupling to the sensitive equipment. This ground plane may be isolated from the rest of the floor grid but must be connected to it at at least 1 point.



Applying IEC EMC standards

bonding of apparatus/systems

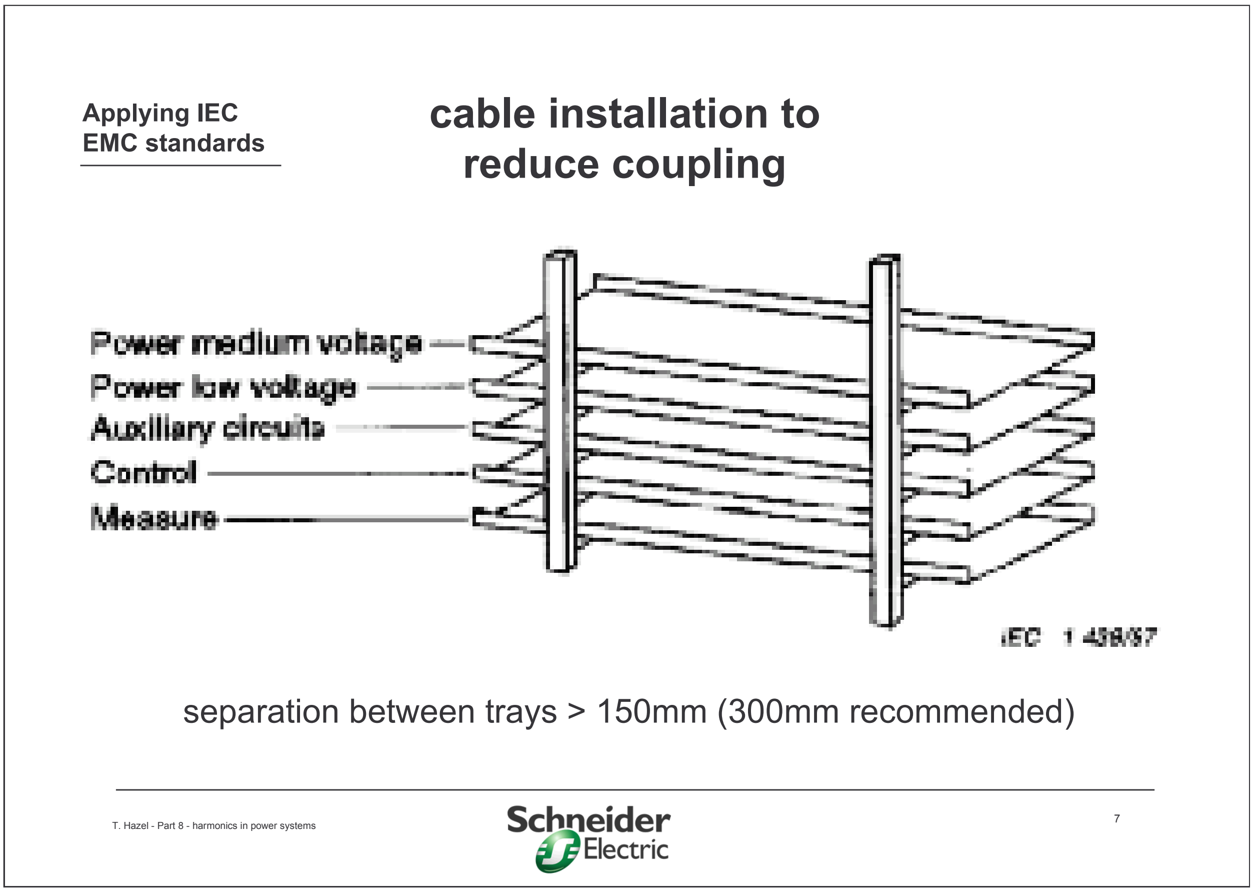
Earth electrode
Earthing network
Lights
Electric equipment
Electronic equipment
Structures
Motors
Neutral
"A"
Voltage reference & cable shields
Plant process
Power Transformer
Cable trays
"B"
"C"
IEC 1 423/97

T. Hazel - Part 8 - harmonics in power systems

Intelligent bonding

Although all earthing conductors are interconnected at some point, it is best not to connect sensitive electronic equipment to the same earthing conductor as power electronic equipment (VFDs for example) to avoid common coupling impedance. Different earthing system zones can be made, one for sensitive equipment, and one for power equipment. These zones are then interconnected by the earthing network.

The electronic equipment is shown connected at one point thereby avoiding potential differences between cubicles due to circulating currents in the earthing network.



cable installation to reduce coupling

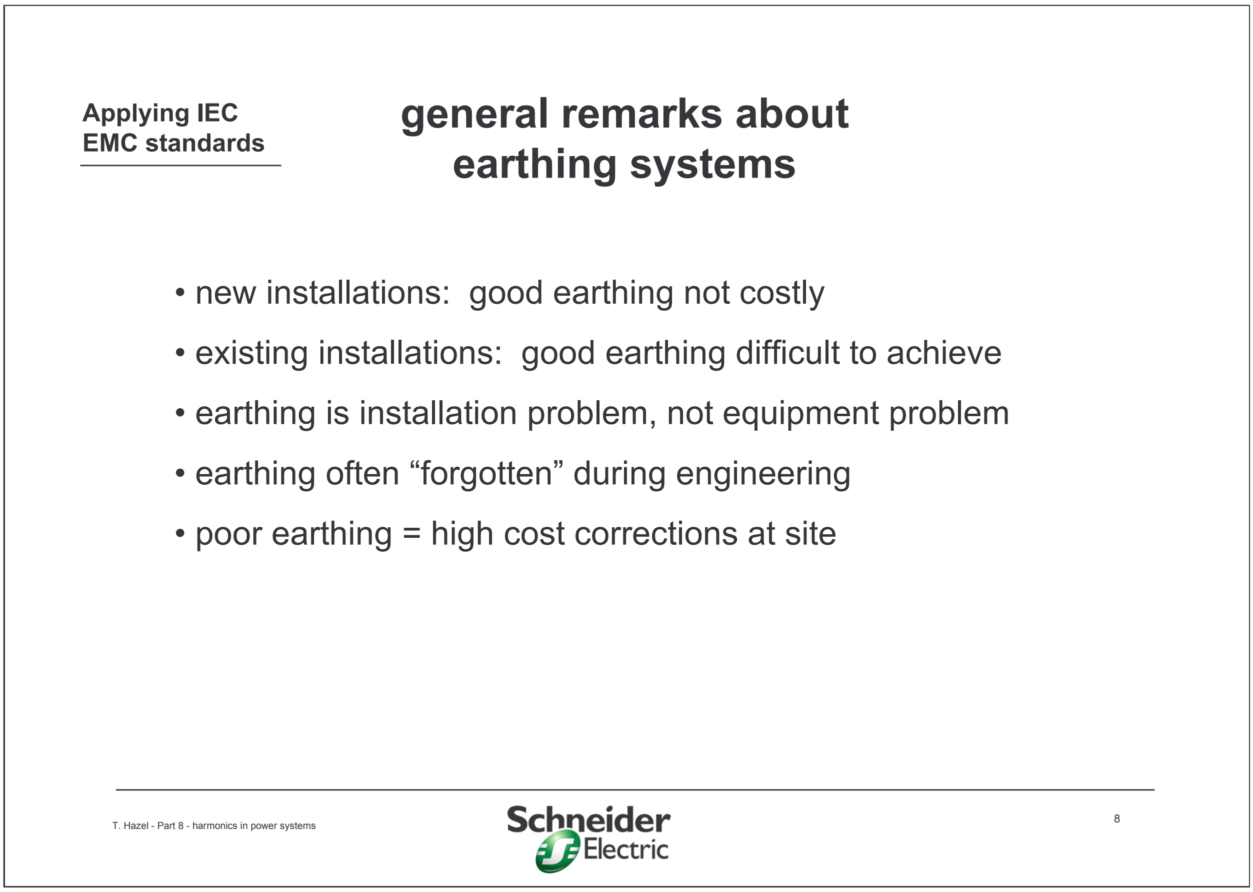
separation between trays > 150mm (300mm recommended)

Cable trays

For better shielding, steel cable trays should be used rather than plastic coated supports. Sensitive circuits should be installed in trays having steel covers. The cable trays must be interconnected by earthing conductors which are connected to the earthing network at regular intervals (10m).

Parallel earthing conductors (PECs) should be installed close to control and measurement cables when installed outside covered trays. These conductors will carry most of the circulating earth current and reduce noise generated in the signal circuits. During fault conditions most current will flow in the PEC preventing damage to shields.

Earthing of PECs, cable shields, etc. should be done using 360° connectors to reduce impedance. Use of pigtails is not recommended since these have too high an impedance to be effective for EMC requirements.



Applying IEC EMC standards

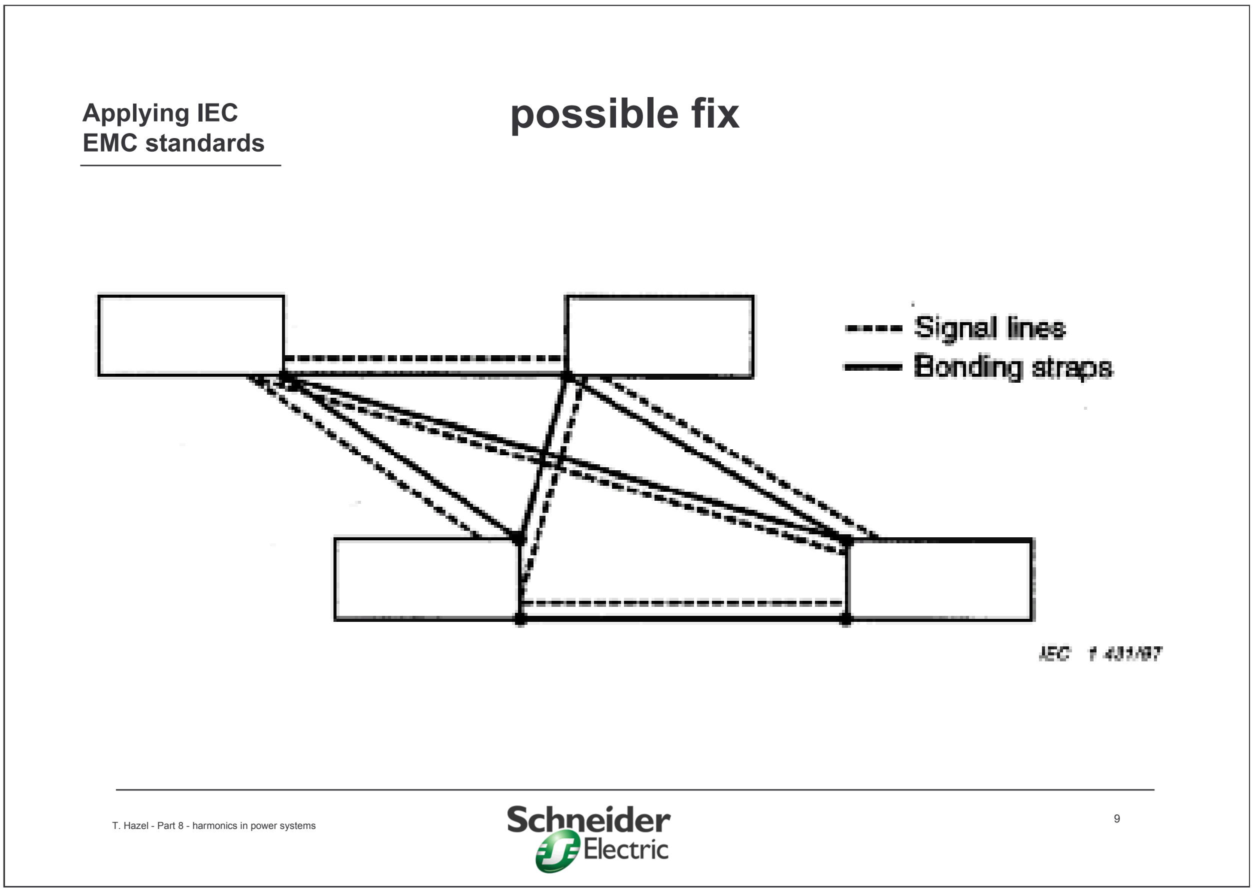
general remarks about earthing systems

- new installations: good earthing not costly
- existing installations: good earthing difficult to achieve
- earthing is installation problem, not equipment problem
- earthing often “forgotten” during engineering
- poor earthing = high cost corrections at site

Design responsibility

The earthing system is common for the complete installation and therefore not the responsibility of equipment suppliers. Each supplier should give particular earthing requirements for correct operation of his equipment. In some cases clarification of the earthing requirements is necessary (I have still seen references to “clean earth” in some manufacturers’ literature).

Not enough design time is spent generally on earthing systems. The earth electrodes must be made at the start of construction. This includes bonding of reinforcing steel in concrete, bonding of structural steel etc. This is often on the critical path and easily missed since construction “waits for no one”. Achieving good earthing in existing structures is difficult and expensive.



possible fix

Fixing a poor design

If the design didn't take EMC requirements into account, it is very difficult to fix it after construction is completed. Several methods of mitigation can be used and some may even give satisfactory results. As shown it is possible to install additional bonding straps which present a lower impedance for circulating currents and help reduce the interference in the signal cables. It is not evident that this will be effective at high frequencies where the geometry of the installation is more important than the cross section of the cables.

In general the cost of fixing a poor design greatly exceeds the cost of installing a good earthing system from the start. Properly designed earthing systems are basically just bare copper conductors and therefore hardly appear as a cost item in projects. Fixing one is expensive due to the installation after construction of the copper conductors and also due to the amount of down time resulting from EMC related shut downs.